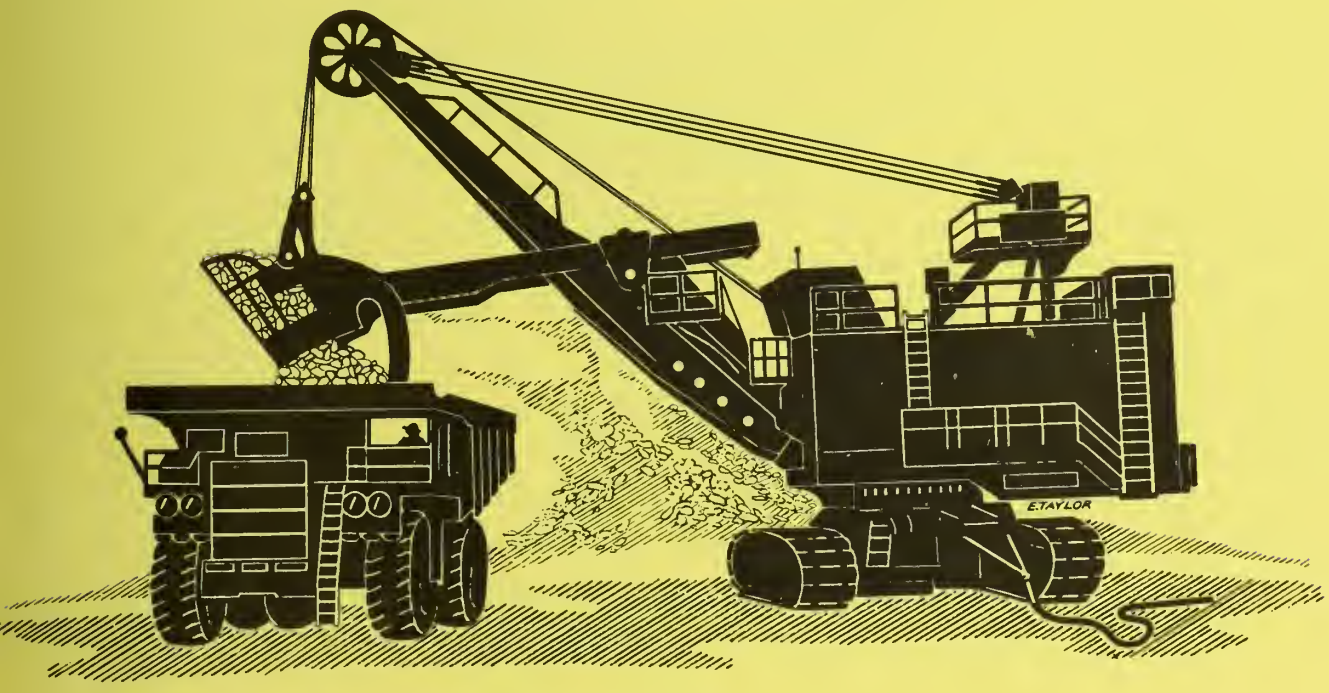
S

PHYSICAL SCIENCES
LIBRARY
UC DAVIS

MINERAL COMMODITY REPORT
—— LIME ——
(QUICKLIME, HYDRATED LIME, AND DEAD-BURNED DOLOMITE)

1984



CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

UNIVERSITY OF CALIFORNIA
DAVIS
MAY 31 1985
GOV'T. DOCS. - LIBRARY

SPECIAL PUBLICATION 73

STATE OF CALIFORNIA • RESOURCES AGENCY • MINES AND GEOLOGY • DEPARTMENT OF CONSERVATION

STATE OF CALIFORNIA
GEORGE DEUKMEJIAN
GOVERNOR

THE RESOURCES AGENCY
GORDON K. VAN VLECK
SECRETARY FOR RESOURCES

DEPARTMENT OF CONSERVATION
DON L. BLUBAUGH
DIRECTOR

DIVISION OF MINES AND GEOLOGY
JAMES F. DAVIS
STATE GEOLOGIST

SPECIAL PUBLICATION 73

MINERAL COMMODITY REPORT
—— LIME ——
(QUICKLIME, HYDRATED LIME, AND DEAD-BURNED DOLOMITE)

1984

By
Marjorie M. Bushnell

Part I from
Mineral Commodity Summaries, 1984
U.S. Bureau of Mines publication,

CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES GEOLOGY
1416 NINTH STREET
SACRAMENTO, CALIFORNIA 95814

Digitized by the Internet Archive
in 2012 with funding from
University of California, Davis Libraries

http://archive.org/details/mineralcommodity73bush

CONTENTS

		Page
INTRODUCTION		1
PART I: UNITED STATES AND WORLDWIDE		
1.	United States Production and Use	3
2.	Salient Statistics -- United States	3
3.	Recycling	3
4.	Import Sources	4
5.	Tariff	4
6.	Depletion Allowance	4
7.	Federal Government Stockpile	4
8.	Events, Trends, and Issues	4
9.	World Mine Production and Reserve Base	5
10.	World Resources	5
11.	Substitutes	5
Part II: CALIFORNIA		
12.	California Geological Occurrences	7
13.	California Localities	7
14.	California Production	8
15.	Utilization and Markets	9
16.	Mining Methods and Beneficiation	9
17.	California Events, Trends, and Issues	10
18.	References	11

INTRODUCTION

This report on the availability and demand for lime in California, the United States, and the world is one of a series of Mineral Commodity Reports prepared by the California Department of Conservation, Division of Mines and Geology (DMG) to describe commodities of significance to California and the nation.

This mineral commodity report was compiled by Marjorie M. Bushnell of the DMG geologic staff. Part I consists of United States and world-wide mineral-statistic information and economic analysis, adopted directly from the U.S. Bureau of Mines "Mineral Commodity Summaries, 1984." Part II discusses production of the commodity in California. The U.S. Bureau of Mines presents the earliest government estimates of non-fuel mineral-industry data, including world resource data provided by the U.S. Geological Survey.

Lime is the common name for calcium oxide (CaO), which is obtained principally from calcining limestone although other calcium sources such as gypsum, brines, and industrial by-products are substantial. The alkaline properties of lime and its low-cost widespread availability make it useful in such applications such as (1) the manufacture of industrial and agricultural chemicals and pharmaceutical products, (2) decreasing the expansive properties of certain clay soils, and (3) neutralizing acid conditions present in industrial effluent and in waste-water treatment.

Nationwide in 1983, lime producers sold or used 14,400,000 tons of lime valued at $727 million. Of this California produced 363,777 tons valued at $23 million. Much of the California total included lime for sugar-refinery use, but substantial amounts were utilized by industry. One major user, Kaiser Steel Corporation at Fontana, ceased operation during the year.

For further information, please call (916) 445-5716, the DMG centralized information number.

PART I: UNITED STATES AND WORLDWIDE

1. UNITED STATES PRODUCTION AND USE

In 1983, lime producers at 147 plants in 39 states sold or used 14.4 millon tons of lime valued at 727 million, an increase of 2% in tonnage and essentially the same total value compared with that of 1982. Open-market sales increased 7% to 11.7 million tons. Captive lime used by producers decreased 16% to 2.7 million tons, which was 63% below the record year of 1971. Ten companies, operating 31 plants, accounted for 51% of the output. Principal producing states were Ohio, Missouri, Kentucky, Pennsylvania and Texas. Each produced over 1 million tons, and together accounted for 48% of the output. The leading individual uses for lime were in steel furnaces, water treatment, construction, and paper and pulp. Dead-burned dolomite was in decreasing demand for refractories. Sales for chemical and industrial uses were 89%, construction 8%, and refractories 3%. Agricultural use was minor. Chemical and industrial sales were up 6%, construction sales were vitually the same, refractory sales were up 70%, and sales of lime for agriculture increased 23% compared with 1982.

2. SALIENT STATISTICS -- UNITED STATES

(Data in thousand short tons, unless noted)

	1979	1980	1981	1982	1983[e]
Production	20,945	19,010	18,856	14,075	14,400
Imports for Consumption	640	480	504	348	325
Exports	45	42	28	23	25
Apparent consumption	21,540	19,448	19,332	14,400	14,700
Price: Dollars per ton at plant, average	41.18	44.34	46.89	49.46	50.50
Stocks, yearend		Not available			
Employment: Mine and plant	6,500	6,500	6,500	5,200	5,100
Net import reliance[1] as a percent of apparent consumption	3	2	2	2	2

3. RECYCLING

Large quantities of lime are regenerated by paper mills, carbide plants, and some municipal water treatment plants. Data for these plants are not included as production, in order to avoid duplication.

---

e Estimated.

1 Defined as imports - exports + adjustments for Government and industry stock changes.

4. IMPORT SOURCES (1979-82)
Canada 94%, Mexico 6%.

5. TARIFF

Item	Number	Most favored Nation (MFN)		Non-MFN
		1/1/84	1/1/87	11/1/84
Hydrated	512.11	Free	Free	12¢/100lb[2]
Other	512.14	Free	Free	10¢/100lb[2]

6. DEPLETTION ALLOWANCE

14% (Domestic), 14% (Foriegn), for limestone produced and used for lime production.

7. GOVERNMENT STOCKPILE

None.

8. EVENTS, TRENDS, AND ISSUES

Sales for environmental uses increased slightly compared with that of 1982. Enviornmental regulations have increased demand for lime for desulfurizing stack gases of thermal powerplants, smelters, refineries, chemical plants, and for neutralizing industrial effluent water and solid wastes. Captive use was down 8%, influenced by the iron and steel industry, which operated at less than 55% of capability in 1983. Two open-market plants in Ohio ceased operations in 1983 and two plants, one in Florida and one in Pennsylvania, resumed operation. One new dolomitic lime plant in Texas came onstream in 1983. Estimated shipments, sold or used, represented 60% national utilization of capacity. From a 1982 base, demand for lime is expected to increase at an annual rate of about 3% through 1990. It is estimated that in 1984 domestic production of lime will be 15.1 million tons and U.S. apparent consumption will be 15.4 million tons.

The lime industry is energy intensive, averaging about 7.0 million Btu per ton of lime produced. About 83% of the industry is energy intensive, averaging about 7.0 million Btu per ton of lime produced. About 83% of the industry used coal and coke, 15% used natural gas, and the balance used other fuels. Natural gas is presently 50% to 100% more expensive than coal in most areas. In 1983, two new plants used pulverizesd coal; current trends indicate a greater use of coal.

---

2 Rates include weight of container.

9. WORLD MINE PRODUCTION AND RESERVE BASE

	Production		Reserve Base*
	1982	1983e	
United States[3]	14,112	14,400	
Belgium	3,000	3,100	
Brazil	5,500	5,700	
Canada	2,415	2,500	
Chile	600	700	Adequate for
France	3,750	3,900	for all
Germany, Federal Republic of	8,800	9,000	countries
Italy	2,535	2,700	listed
Japan	8,800	9,500	
Other Market Economy Countries	23,940	24,600	
U.S.S.R.	27,600	28,000	
Poland	8,270	8,300	
Other Centrally Planned Economies	14,082	14,500	
World Total (may be rounded)	123,400	126,900	

10. WORLD RESOURCES

Domestic and world resources of limestone and dolomite suitable for lime manufacture are adequate.

11. SUBSTITUTES

Limestone is a substitute for lime for many uses such as agriculture, fluxing, and sulfur removal. Although less reactive, limestone is considerably cheaper than calcined energy-intensive lime. Calcined gypsum is an alternate material in industrial plasters and mortars. Cement kiln dust is a potential resource as a substitute for lime.

3 Includes Puerto Rico.

* Pending establishment of criteria for the reserve base, classification of data is based on judgemental appraisal of current knowledge.

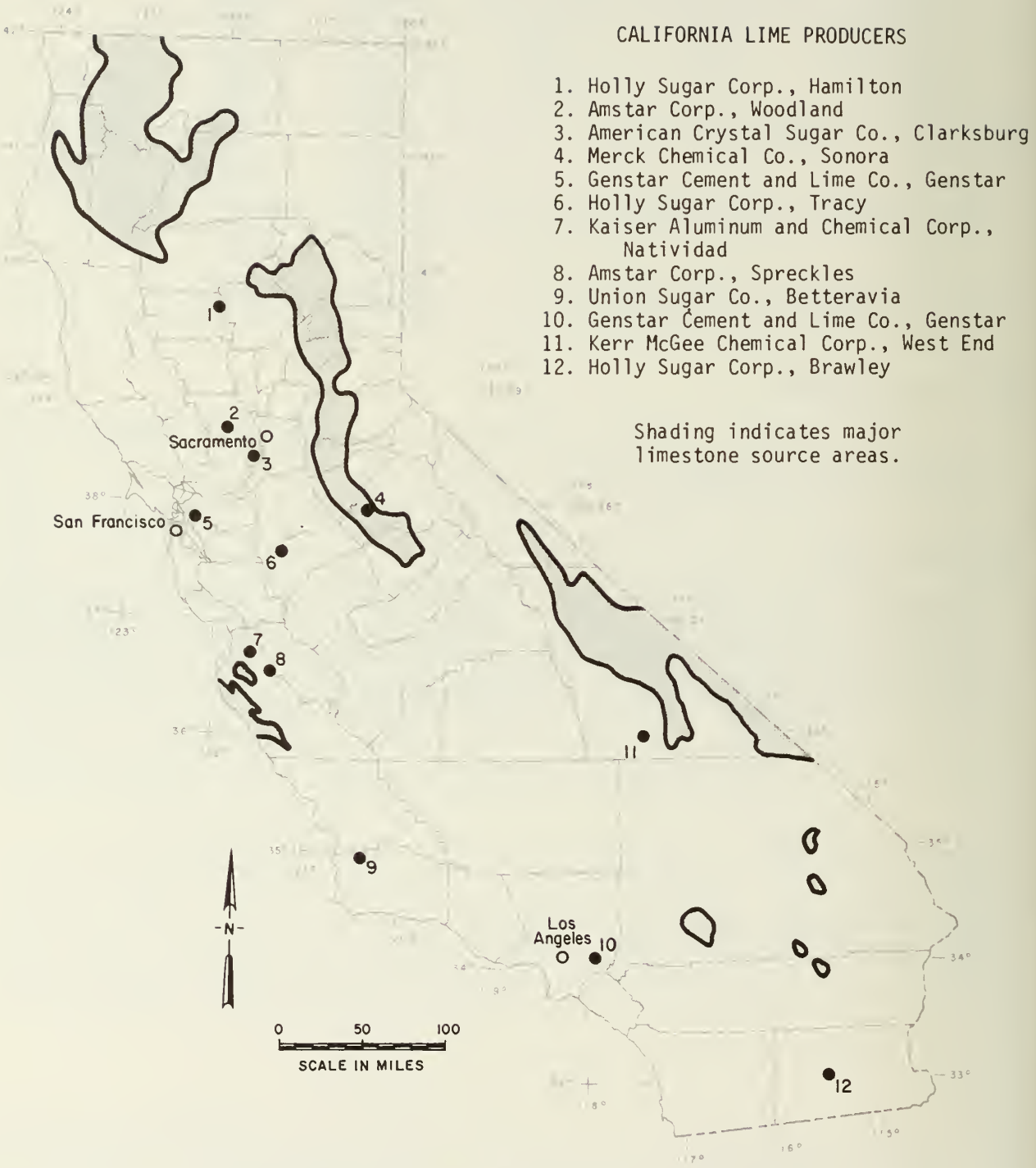

CALIFORNIA LIME PRODUCERS
1. Holly Sugar Corp., Hamilton
2. Amstar Corp., Woodland
3. American Crystal Sugar Co., Clarksburg
4. Merck Chemical Co., Sonora
5. Genstar Cement and Lime Co., Genstar
6. Holly Sugar Corp., Tracy
7. Kaiser Aluminum and Chemical Corp., Natividad
8. Amstar Corp., Spreckles
9. Union Sugar Co., Betteravia
10. Genstar Cement and Lime Co., Genstar
11. Kerr McGee Chemical Corp., West End
12. Holly Sugar Corp., Brawley
Shading indicates major limestone source areas.
Sacramento
San Francisco
Los Angeles
-N-
0 50 100
SCALE IN MILES

Figure 1. Locations of California limestone deposits and lime producers.

PART II: CALIFORNIA

12. CALIFORNIA SOURCES

Lime is available in California from several sources including: (1) calcining of limestone, (2) delayed-release directly from crushed limestone, (3) other calcium minerals, and (4) as a by-product of limestone used for other purposes.

California contains vast reserves of limestone, irregularly distributed throughout the state. Most of these deposits are made up of sedimentary rocks which originated (along with lesser sand, clay, and other impurities) at former continental boundaries. In general the rocks are Precambrian and Paleozoic in age, preserved by subsequent uplift. Small deposits of calcium carbonate, now limestone, also formed by hydrothermal deposition from carbonate-laden springs, or by evaporation of carbonate-bearing surface water. At some coastal locations, shells, which consist primarily of calcium carbonate, are available as the result of present-day dredging operations or as older accumulations preserved and now exposed as bedrock.

Limestone ($CaCO_3$) will provide lime (CaO) over a long period of time if crushed, worked into soil, and subjected to the action of water and other chemicals. This reaction is more rapid in acid soils, in which the presence of $CaCO_3$ tends to correct the acid condition, and is ineffective in alkaline soils in which limestone, if used at all, is used to correct textural problems.

Other calcium minerals such as gypsum ($CaSO_4$), apatite ($Ca_5(PO_4)_3F$) and calcium salts are potential sources of CaO, either directly or as a by-product of the extraction of other elements from the mineral. Thus the removal of phosphorus, a fertilizer component in high demand, from apatite would provide excess lime. Substantial deposits of apatite-bearing rock (phosphorite) are present, but as yet undeveloped, in California.

Limestone as a source of carbonate (CO_3) for industrial use such as the carbonation of sodium from brines, the purification of sugar, or the control of acidic industrial waste may result in surplus CaO as a marketable product. Since lime of this type is available regardless of lime-market factors, it provides a significant competition to other sources.

13. CALIFORNIA LOCALITIES

Major limestone deposits are located in the Klamath Mountains, the Coast Ranges, the Sierra Nevadas, the Basin Ranges Province, the Mojave Desert, and the Transverse and Peninsular Ranges (Figure 1). These provinces, in general, contain sedimentary rocks of near-continent marine origin, including remnants left after intrusion by the granite of the great California batholiths. Areas particularly notable include the Coyote and Fish Creek Mountains of Imperial County, Black Canyon in the Tehachapi district of Kern County, the north slopes of the central San Bernardino Mountains, the Marble Mountains and Cima area of eastern San Bernardino

County, the Keeler area in Inyo County, the Lake Hemet vicinity and Maria Mountains of Riverside County, the Frazier Park area of Ventura County, the San Marcos Pass vicinity of Santa Barbara County, Pico Blanco in Monterey County, the Murphys-Columbia-Sonora area of the central Sierra Nevada, the Volcano vicinity in Amador County, and the Lake Shasta area of Shasta County. Much of the material derived from these deposits is suitable for calcining to lime.

Saline basins of the Mojave Desert have been exploited for a variety of minerals, including calcium salts. Additionally, chemical products produced by the Kerr-McGee Company form brines at Searles Lake leave a lime by-product which is marketed as CaO.

In San Francisco Bay shells obtained by dredging provide a potential lime resource. Shell deposits at Newport Beach have been exploited for this purpose in the past. Current lime producers shown in Figure 1 include all locations listed by the U.S. Bureau of Mines as active during 1983 (although at some locations production may be primarily for use within the company). Additional lime resources may be presumed from producers who have extracted limestone essentially for rock purposes or as the result of dredging operations. DMG's 1983 list of active California mineral producers (Silva and others, 1983) lists the following suppliers of lime and miscellaneous-purpose limestone:

Amstar Corp.	El Dorado County
El Dorado Limestone Co.	El Dorado County
Graniterock Company	Monterey County
Kerr-McGee Chemical Corp.	Inyo County
M and C Marble	Inyo County
Metaline Industries	Inyo County
Monarch Quarries	Kern County
Morris Shell and Dredging Co.	Contra Costa County
Pfizer, Inc.	San Bernardino County
Pleuss-Staufer, Inc.	San Bernardino County
Whittaker, Norman A.	San Bernardino County

14. CALIFORNIA PRODUCTION

U.S. Bureau of Mines data indicate that lime production during 1982 in California was 363,777 short tons, having a value of $23,000,408. This consisted of 335,258 tons ($20,252,489) as quicklime and 28,519 tons ($2,747,919) as hydrate. Producing companies shown on Figure 1, were located in Contra Costa, Glenn, Imperial, Los Angeles, Monterey, San Bernardino, San Joaquin, Santa Barbara, Tuolumne, and Yolo counties.

Much of the lime material included in these figures is the product of California's extensive sugar-beet refining industry. The neutralizing effect on acids, both in industry and agriculture, constituted much of the remaining use. Although much of California's soil is alkaline, some mountainous areas have soils sufficiently acidic to benefit by lime additives. During 1983, 27,666 short tons of lime was used for agricultural purposes. Lime is used in many areas to lessen the expansive properties of certain clay soils.

15. UTILIZATION AND MARKETS

Lime is used to manufacture industrial and agricultural chemicals and pharmaceutical products. Industrial chemicals made with lime include calcium carbide, alkali compounds, and antifreeze. Lime is also used to make chlorinated hydrocarbons and pesticides, and to neutralize reagent solutions and waste effluents.

In beet-sugar production, lime is blended with raw beet juices to form calcium sucrate, which is relatively insoluble. The sucrate is then processed with carbon dioxide, which causes calcium carbonate to precipitate, leaving soluble sucrose. The carbon dioxide used comes directly from the calcining kilns that produce lime.

Expansive soils result from clays that contain sodium or potassium in their structure and that, for this reason, allow water molecules to adhere easily. Substitution of calcium, provided by mixing lime into the soil, significantly decreases the effect. Thus soil problems related to providing a stable base for highways or buildings can be mitigated by the admixture of lime.

Waste-water treatment is another expanding market for lime. Most sewage that enters treatment plants is acidic and must be neutralized to promote efficient biological breakdown of sewage components. Lime is generally used as this neutralizing agent. Flocculation of particulate material is enhanced by the addition of chemicals such as alum, ferric chloride, or calcium hydroxide. Lime as calcium hydroxide is the cheapest and easiest to use, and does not pollute treatment-plant effluent if too much is added.

"Lime scrubbing" is the term used to describe the process for the removal of sulfurous gasses from industrial smoke. The lime scrubber uses the ability of lime to neutralize acids. Hot stack gases are routed through an aqueous lime solution which is kept agitated by physical means to prevent buildup of insoluble residues and caked lime. As the sulfurous gases pass through the solution, sulfur dioxide chemically combines with calcium hydroxide to form calcium sulfate. The calcium sulfate is similar to natural gypsum and may be used in Portland cement, as a raw material for gypsum wallboard, or as an agricultural soil additive.

16. MINING METHODS AND BENEFICIATION

Production of lime involves three main processes--stone preparation, calcination, and hydration. Limestone is quarried by ordinary open-pit methods to avoid silica, alumina, and iron oxide impurities. It is crushed, screened, and sometimes washed to produce kiln-sized stone.

Lime is a calcined (or burned) form of limestone, commonly known as quicklime, calcium oxide, or calcia, or, when water is added, as calcium hydroxide or slaked lime. The term is frequently used to denote almost any kind of calcareous material or finely-ground form of limestone or

dolomite. Lime is usually made from limestone having a minimum of 97% carbonate content. Normally, high-calcium limes contain less than 5% magnesia (MgO). When the lime is produced from a high-magnesium limestone, the product is referred to as dolomitic lime.

Calcination refers to reactions wherein substances are heated to less than their melting points. In the calcination of limestone to produce lime, the basic chemical reaction is:

$CaCO_3$ (limestone) + heat (1000° to 1200°C) = CaO (quicklime) + CO_2
100 56 44

Calcination is a time-variant process because the reaction starts on the exterior surface of the limestone and then proceeds toward the center. Natural impurities in the stone, differences in crystallinity, grain boundary chemistry, density variations, and imperfections in the atomic lattice play a significant role in the rate.

Because the reaction is chemically reversible, the quicklime or burned lime product is highly reactive or unstable. The more stable form of lime, hydrated lime, is commonly preferred to avoid uncontrolled hydration and associated generation of heat. Hydrated lime is obtained by adding water to quicklime to produce a dry, fine powder.

17. CALIFORNIA EVENTS, TRENDS, AND ISSUES

Shortage of lime and limestone during the 1970s resulted from increased urbanization and reluctance to allow mining near inhabited areas. This and increased fuel costs during the same period resulted in a shortage of lime and lime products that was relieved only by the large drop in construction during the subsequent few years. Closure of Kaiser Steel Corporation's Fontana plant during 1984 removed a major user from the marketplace. The demand for lime may now be expected to increase from the present level because of the strengthened economy and because the pollution-control properties will be increasingly in demand.

Environmental effects associated with quarrying limestone are primarily visual or associated with haulage, since the material itself has few deleterious qualities. Because the exposed rock face that sometimes remains after quarrying is difficult to shape to a natural appearance, and often will not support vegetation, local objections sometimes restrict quarrying to remote or unobtrusive locations. As a result, transportation costs from increasingly distant areas can be expected to rise proportionally.

Although lime resources overall are large and the United States is self-sufficient in this commodity, the reserves of chemically-pure limestone are limited and decreasing due to being mined-out, increasing restrictions, and competition for land use.

18. REFERENCES

Bates, R.L., 1969, Geology of the industrial rocks and minerals: Dover Publications, Inc., New York, p. 156-178.

Bowen, O.E., 1966, Limestone, dolomite, and lime products, in Mineral resources of California: California Division of Mines and Geology Bulletin 191, p. 221-233.

Bowen, O.E., Gray, C.H., Jr., and Evans, J.R., 1973, The mineral economics of the carbonate rocks: California Division of Mines and Geology Bulletin 194, 60 p.

Boynton, R.S., Gutschick, K.A., Freas, R.C., and Thompson, J.L., 1983, Lime, in Industrial Minerals and Rocks, 5th edition: American Institute of Mining and Metallurgical Engineers, p. 809-831.

Jenkins, O.P., 1951, Minerals useful to California agriculture: California Division of Mines Bulletin 155, 148 p.

Rapp, J.S., 1976, Lime industry in California: California Geology, v. 29, p. 219-223.

Silva, M.A., Burnett, J.L., Rapp, J.S., and Cole, K., 1983, Mines and mineral producers active in California: California Division of Mines and Geology Special Publication 67, p. 15-16.

U.S. Bureau of Mines, J.W., 1984, Lime, in Mineral commodity summaries 1984, p. 88-89.